ExperCAT 1.2 Expert System User's Manual

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ABSTRACT

ExperCAT is a menu-driven "Clear Air Turbulence Forecast Expert System" that runs on an IBM-PC-AT or compatible computer. The purpose of ExperCAT is to provide nowcasts and short term forecasts of upper-level turbulence using satellite and upper air data, which are input by the user. Clear air turbulence (CAT) is nonconvective turbulence that occurs at altitudes above 18,000 ft. While the user is asked questions about current upper air and satellite data, ExperCAT uses these answers in a "chain of reasoning" process to arrive at a CAT forecast.

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ExperCAT 1.2 EXPERT SYSTEM USER'S MANUAL

1. SCOPE

1.1 Identification

This User's Manual applies to the expert system known as "Clear Air Turbulence Forecast Expert System" (ExperCAT) Version 1.2. ExperCAT is currently available in a format that runs on an IBM-PC-AT or compatible computer.

1.2 System Overview

The main purpose of ExperCAT is to provide nowcasts and short term (<=6 h) forecasts of upper-level turbulence using satellite and upper air data. Clear air turbulence (CAT) is nonconvective turbulence that occurs at altitudes above 18,000 feet. The analysis and prediction of CAT is a difficult problem because it exists in relatively small areas and tends to change rapidly with time. The ability to analyze and forecast CAT requires a highly specialized, and therefore rare, expertise. Because it is a mesoscale phenomenon, CAT is difficult to diagnose by using relatively coarse (horizontal and temporal) resolution upper-air data measurements. For this reason, the focus of turbulence detection has shifted to the use of satellite imagery. Both orbiting and geostationary satellites are able to provide enough temporal and spatial resolution to detect CAT-producing conditions, assuming that such conditions can be related to cloud signatures seen on the image. Turbulence intensities referred to in ExperCAT are those experienced by large aircraft.

On-line "help" information provides explanations of the questions presented to the user and justification for answers chosen by the expert system. Other ExperCAT features include illustrated examples of synoptic and satellite patterns and a reasoning summary of the final forecast choice. All of these features enhance the expertise of the user.

1.3 Document Overview

The purpose of this manual is to provide users of ExperCAT instructions sufficient to load and execute the program and measures to be taken if error messages occur.

2. SOME USEFUL DOCUMENTS FOR ADDITIONAL INFORMATION

Ellrod, G.P., 1985: Detection of High Level Turbulence Using Satellite Imagery and Upper Air Data. NOAA Technical Memorandum NESDIS 10, Washington DC 20233, 30 pp.

Ellrod, G.P., 1989: A Decision Tree Approach to Clear Air Turbulence Analysis Using Satellite and Upper Air Data. NOAA Technical Memorandum NESDIS 23, Washington DC 20233, 30 pp.

Fett, R.W., W.A. Bohan and J. Rosenthal, 1984: Navy Tactical Applications Guide Volume 4: Eastern North Pacific Weather Analysis and Forecast Applications. Naval Environmental Prediction Research Facility* Technical Report 83-01, Monterey, CA 93943-5006, pages not sequentially numbered.

Lee, D.R., R.B. Stull and W.S. Irvine, 1979: Clear Air Turbulence Forecasting Techniques. U.S. Air Force Global Weather Center Technical Note 79/001, AFGWC/TS, Offutt AFB, NE 68113, 68 pp plus appendices.

Peak, J.E. 1989: Initial Expert Evaluation and Resultant Modifications to the Satellite Image Analysis Meteorological Expert System (SIAMES) Prototype. Naval Environmental Prediction Research Facility*, unpublished internal report, Monterey, CA 93943-5006, 12 pp plus appendices.

Peak, J.E., and P.M. Tag, 1989: An expert system approach for prediction of maritime visibility obscuration. Mon. Wea. Rev., 117, 2641-2653.

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* Now the Naval Oceanographic and Atmospheric Research Laboratory, Atmospheric Directorate.

3. EXECUTION PROCEDURES

3.1 Overview

This section provides the information and instructions necessary for user interaction with ExperCAT 1.2 in order to carry out its operations. Most of the program execution is self-explanatory, so the emphasis here will be on situations and features the user may not be aware of from ordinary use of the program.

3.2 Starting EXPERCAT; Top-Level Menu

The ExperCAT program consists of an executable file, CAT.EXE and a series of files containing the graphics, XXX.PCX. Typically, these files are copied from a floppy disk to the PC hard disk. However, the program can be run directly from the floppy drive. ExperCAT is invoked by typing "cat" at the command-line prompt. After introductory screens (not shown) are displayed, the user reaches the top-level menu (Fig. 1). The menus are graphics-based and list a set of choices with a lighter-colored bar that can be moved over the desired selection via arrow keys. The "page up" and "page down" keys can also be used to move quickly to the top or bottom. Alternately, the first letter of a choice can be entered, but this approach will always select the first of multiple items beginning with the same letter.

3.2.1 Making a Forecast

The user has two choices on the top-level menu: making a forecast or exiting the program (Fig. 1). Choosing to make a forecast leads to an ExperCAT consultation session and a resulting forecast. Figure 2 shows the available choices once the user opts to make a forecast. The user simply responds to a sequence of such questions, selecting the best answer. The last entry on most menus is the choice of going back to the previous question. This allows the user to revise a previous choice without having to exit and restart the program.

3.2.2 On-Screen Examples

The fourth choice on the menu in Figure 2 allows the user to see examples of the flow described in the first three choices. Choosing "Show Examples" makes a screen presentation of the types of flow in question (Fig. 3), allowing the user to make the best choice

available on the current menu. There are other menus, throughout the program, that have a "Show Examples" feature which will assist the user in making the optimum choice. Figure 4 is another such example, showing carrot-shaped cirrus.

3.2.3 On-line Help Features

Shown at the bottom of each screen is the "help" feature (see Fig. 1). Before the user has selected a menu choice, pressing F1 will show an explanation of why this particular question is being asked (Fig. 5). Similarly, the user can obtain an explanation of the answer chosen. After selecting an answer to the question, but before pressing return, pressing F2 will show the justification for the answer chosen (Fig. 6). These "help" features are a very practical way of enhancing the user's expertise, at least until the user becomes familiar with the program.

3.2.4 Forecast Display

After ExperCAT has evaluated all information gathered during the question/answer phase, a clear air forecast is shown on the screen (Fig. 7). A confidence value, expressed in percent, is also shown. This confidence value is an estimate, based on previous CAT forecasting experiences.

3.2.5 Explanation Feature

At the bottom of the forecast display screen (Fig. 8) are instructions for invoking the explanation feature. By pressing F1 the user can see the rationale used by the program in arriving at the forecast shown. To understand how this feature works the user must keep in mind that ExperCAT is a rule-based expert system. Each rule involves taking known information and drawing a conclusion. Such conclusions then become part of the set of known information such that further conclusions can be made. This process is referred to as the "chain of reasoning." As each conclusion is made, an internal record of the chain of reasoning is kept. The explanation feature is the user's window to this record.

3.3 Sample Case

To make a forecast, the user will need the latest satellite pictures of the area of concern. Ideally, a loop of the past few hours should be used. Realistically, using a few pictures from the

past few hours will suffice. Both the visible and infrared (IR) should be used, and, if available, the water vapor image can be useful in certain situations since ExperCAT does have some questions to ask concerning the water vapor patterns. Also, the latest 500mb analysis (typically heights and temperatures) chart near the time of the satellite pictures is needed. The 300 mb analysis chart will also be useful. Other charts and data may be utilized as each user develops his (her) own style and method of using ExperCAT. The other charts and data to be used will be his (her) own choice. These satellite pictures and weather charts will constantly be referred to as questions are asked by ExperCAT.

Figure 9 shows abbreviated versions of the screens used in this example. This hypothetical case uses a minimum number of screens, where all the choices are relatively clear. Some paths in the chain of reasoning will require more choices and hence, more screens. The choice in screen 1, a "sharply curved ridge or trough," branches to screen 2. Assuming a "trough" is present, that choice leads to screen 3, questioning the type of cirrus present. Here, comparing the IR with the visible satellite picture will help delineate the cirrus as it appears much brighter than lower clouds on the IR. A "sharp, well-defined cirrus edge" prompts the next question, screen 4, asking for a description of the upper-level convergence and temperature gradient. Choosing a "strong convergence, large temperature gradient" leads to the forecast shown on screen 5. A fairly high confidence level of 80% is attained as the choices used in this example are all associated with a high incidence of turbulence. By pressing F1, the user can see the chain of reasoning used by ExperCAT to arrive at the forecast shown.

Users are encouraged to try several hypothetical examples, choosing different options each time. The "Show Examples" option should be used whenever possible. These examples will assist the user in making decisions, especially when the decision is not precisely clear. The user's expertise will increase after each use; then, when making an actual forecast, attention can be focused on current data and interfacing with ExperCAT will be more comfortable.

3.4 Exiting from ExperCAT

After obtaining the forecast and/or viewing the reasoning summary, the user need only press return once (or twice if the reasoning summary was invoked) to return to the opening menu. Or, if the user wishes to abort before finishing a forecast, pressing Esc will bring the user back to the opening menu. Using the down arrow once places the lighter-colored bar over "Exit from ExperCAT;" then, by pressing return once more, the user will exit the program.

4. ERROR MESSAGES

Because ExperCAT is menu-driven, the user is not able to enter an answer that is incorrect or confusing to the system. Therefore, any error messages will be due to system problems. If an ExperCAT "bug" occurs, it will cause the message "PROLOG.ERR Missing." In such a case, the sequence of responses, and other pertinent information (PC type, using hard disk, etc.) should be recorded and sent to NOARL to help in finding the problem. Send to:

Naval Oceanographic and Atmospheric Laboratory
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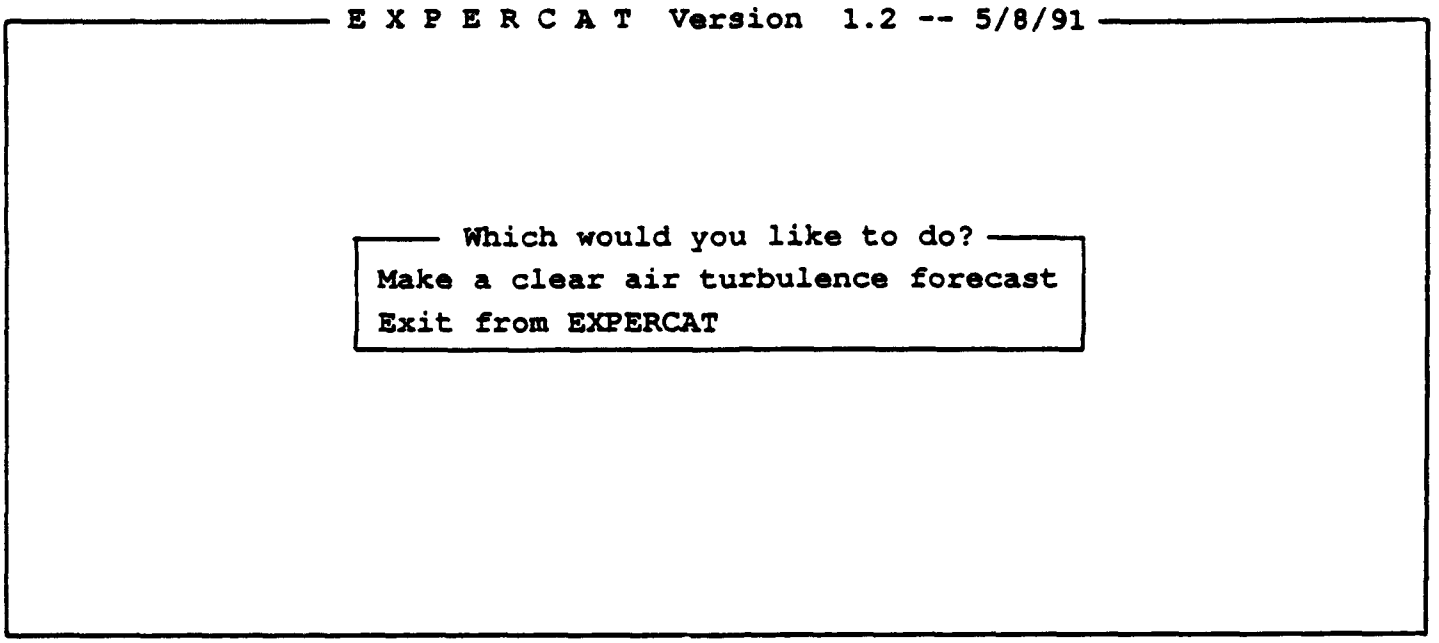


Figure 1. ExperCAT opening screen.

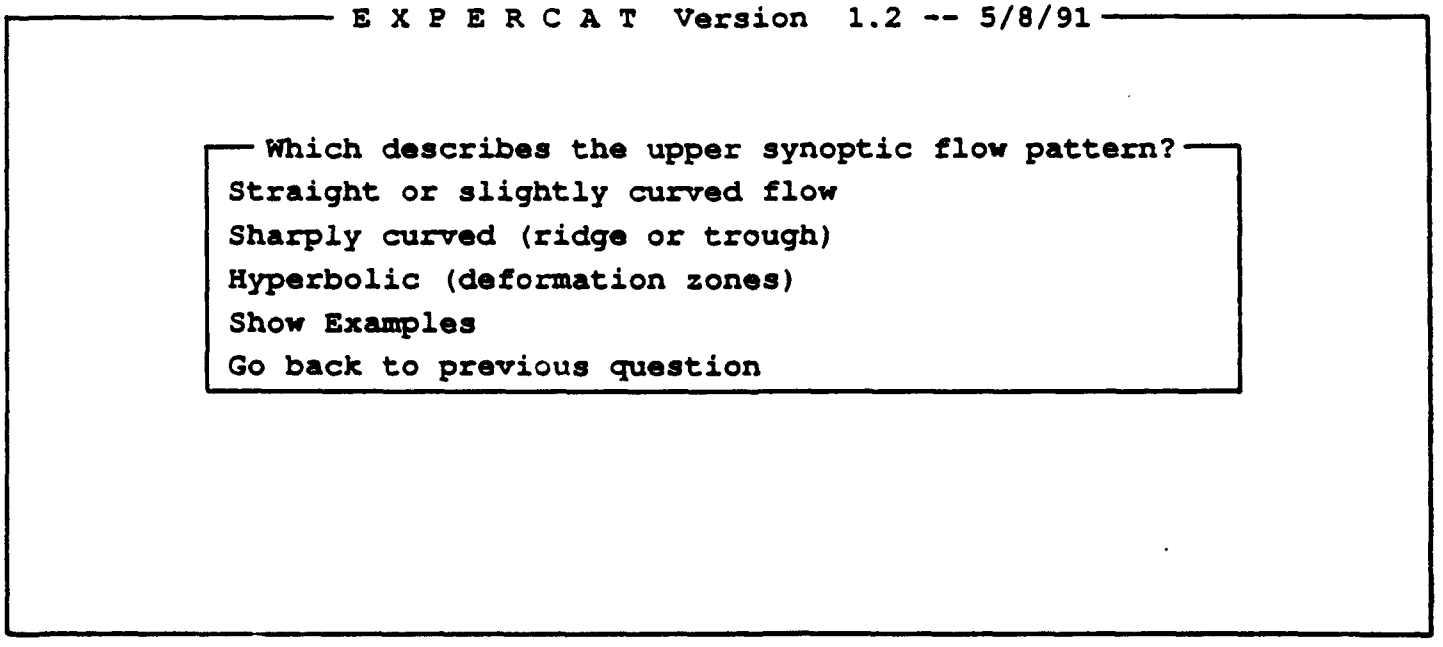
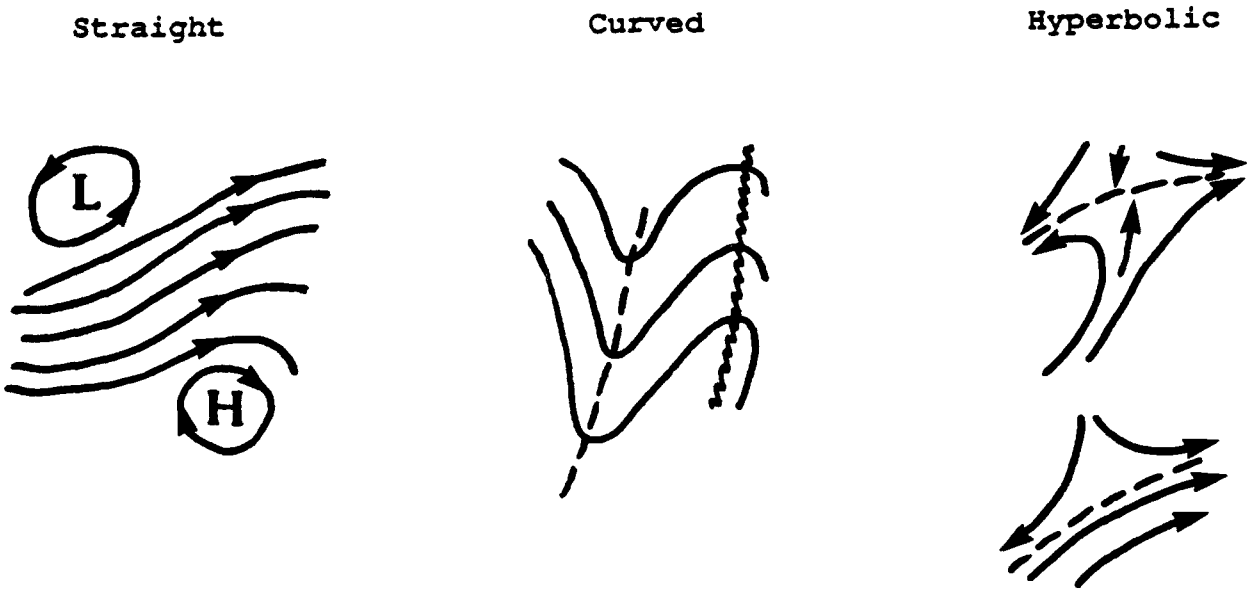
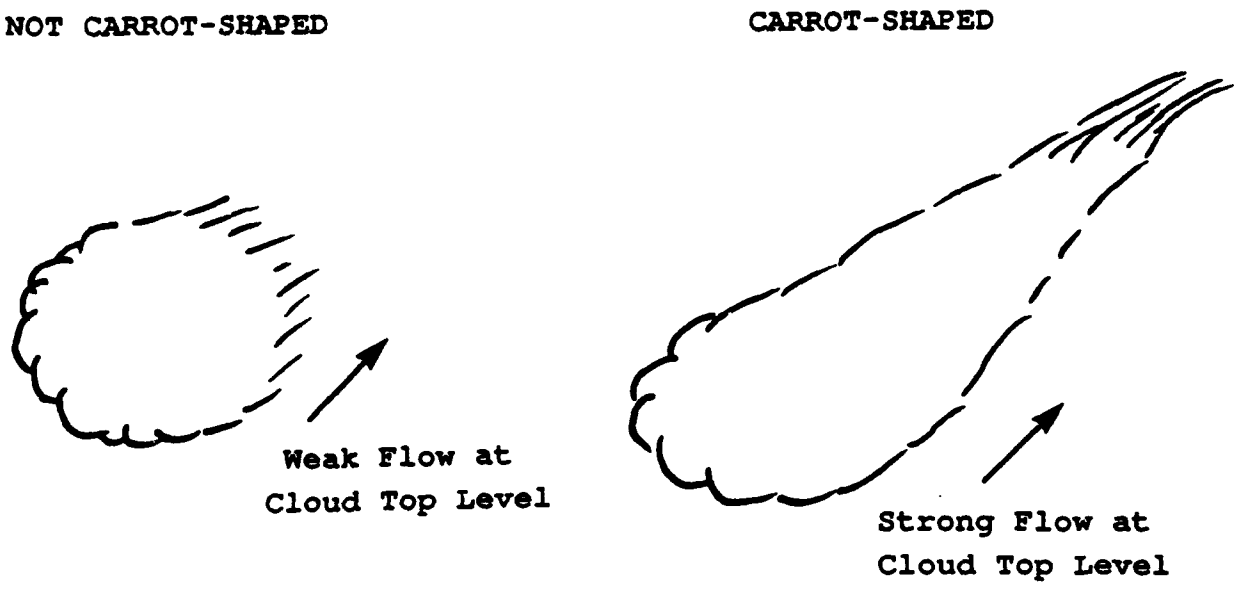


Figure 2. First screen available after user opts to make forecast.



(Press RETURN to continue)

Figure 3. An example of 'Show Examples' option; types of upper flow.



(Press RETURN to continue)

Figure 4. An example of 'Show Examples' option; carrot-shaped cirrus.

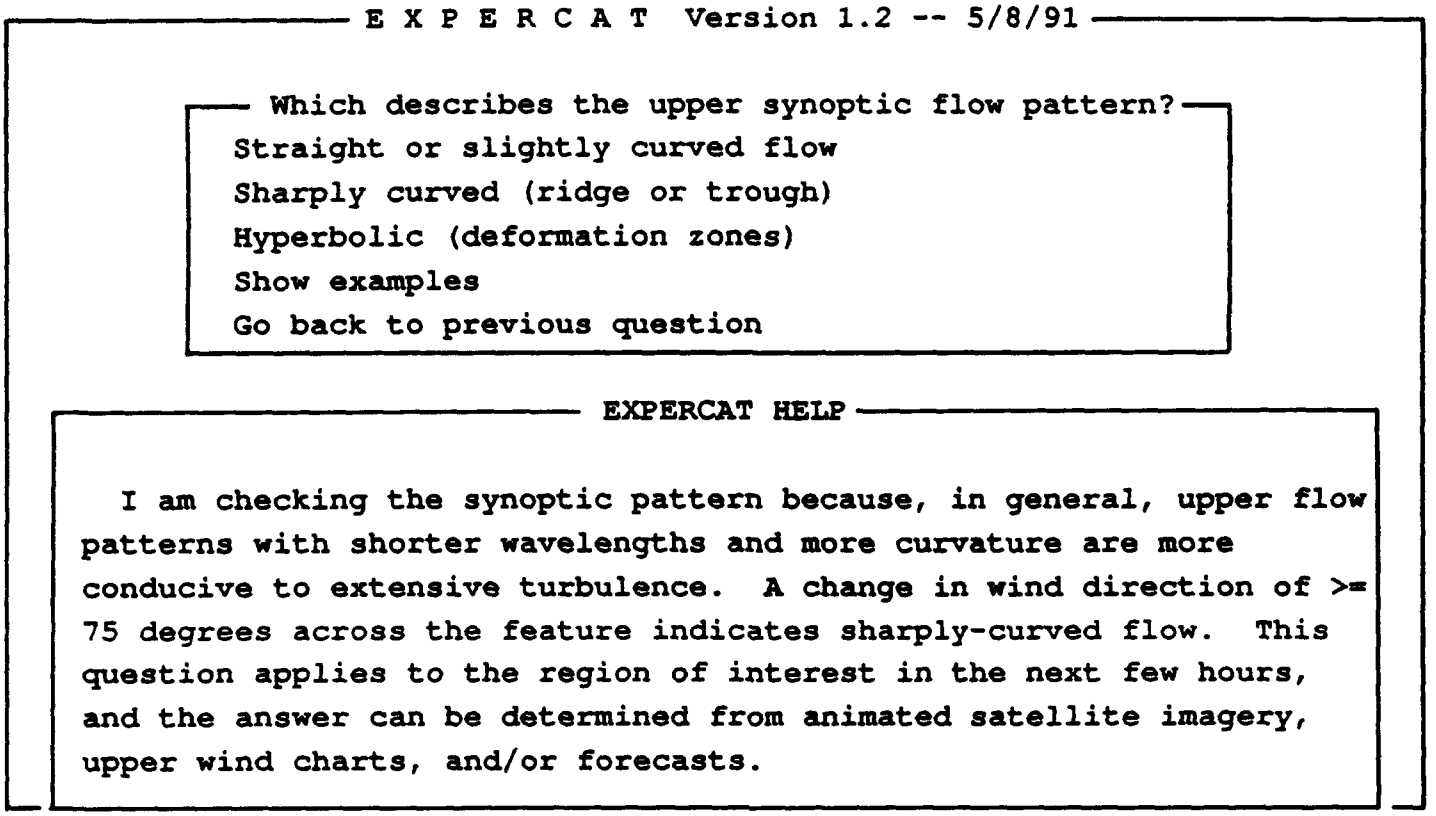


Figure 5. ExperCAT menu invoking optional 'Question Help' feature.

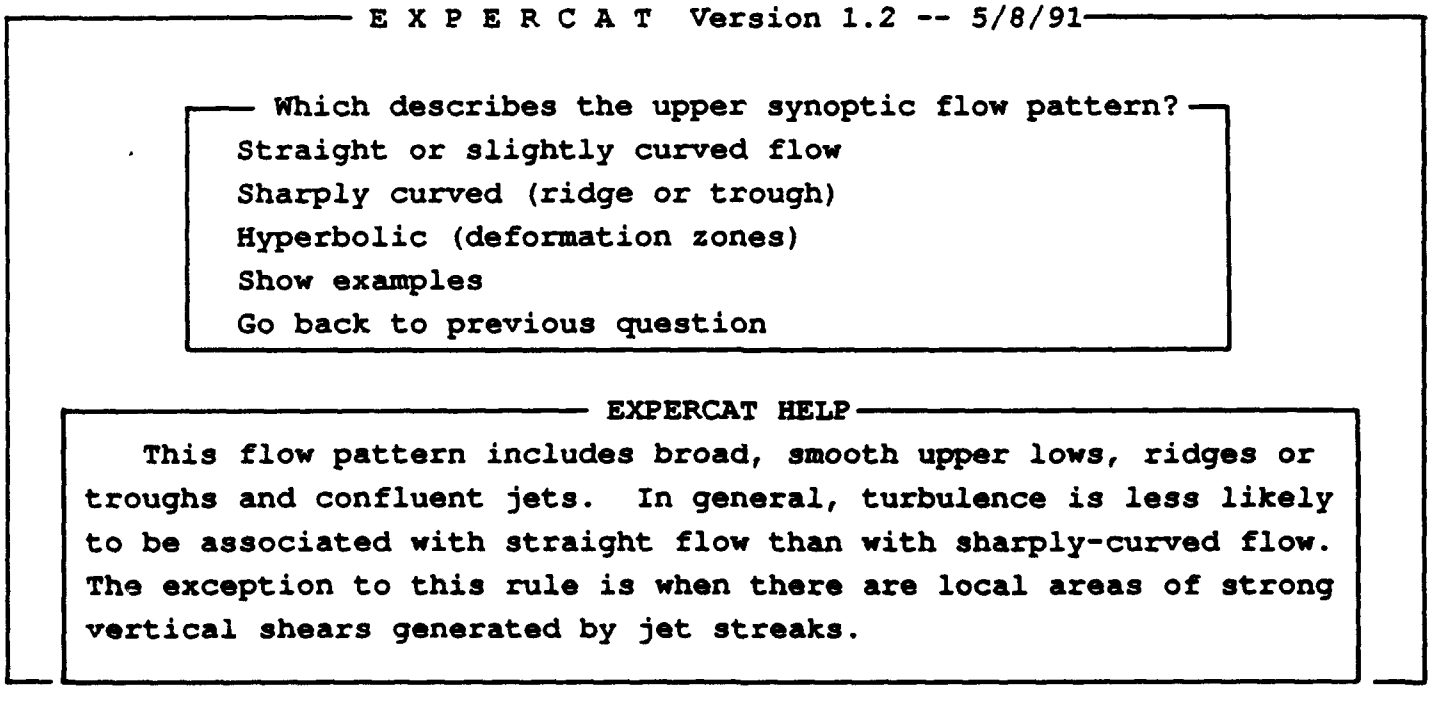


Figure 6. ExperCAT menu invoking optional "Answers Help" feature for "Straight or slightly curved flow."

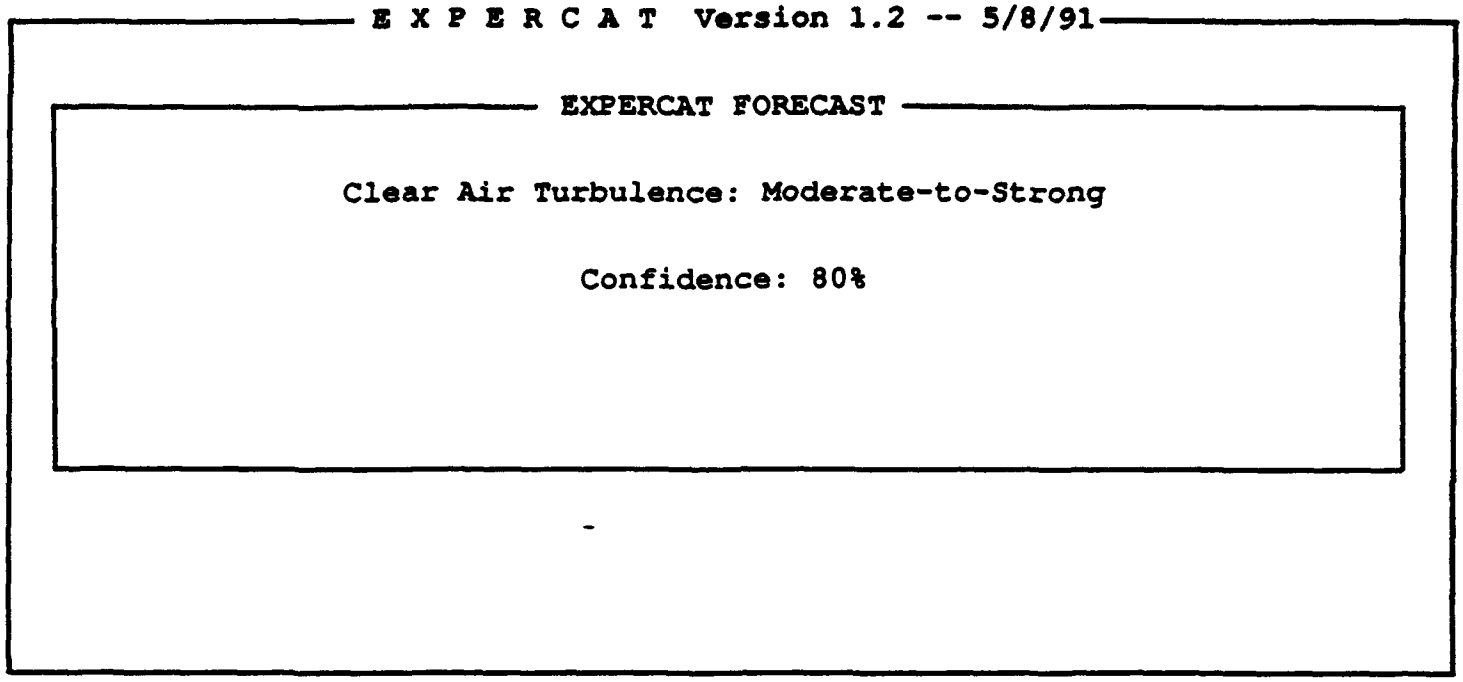


Figure 7. Sample ExperCAT forecast with confidence value.

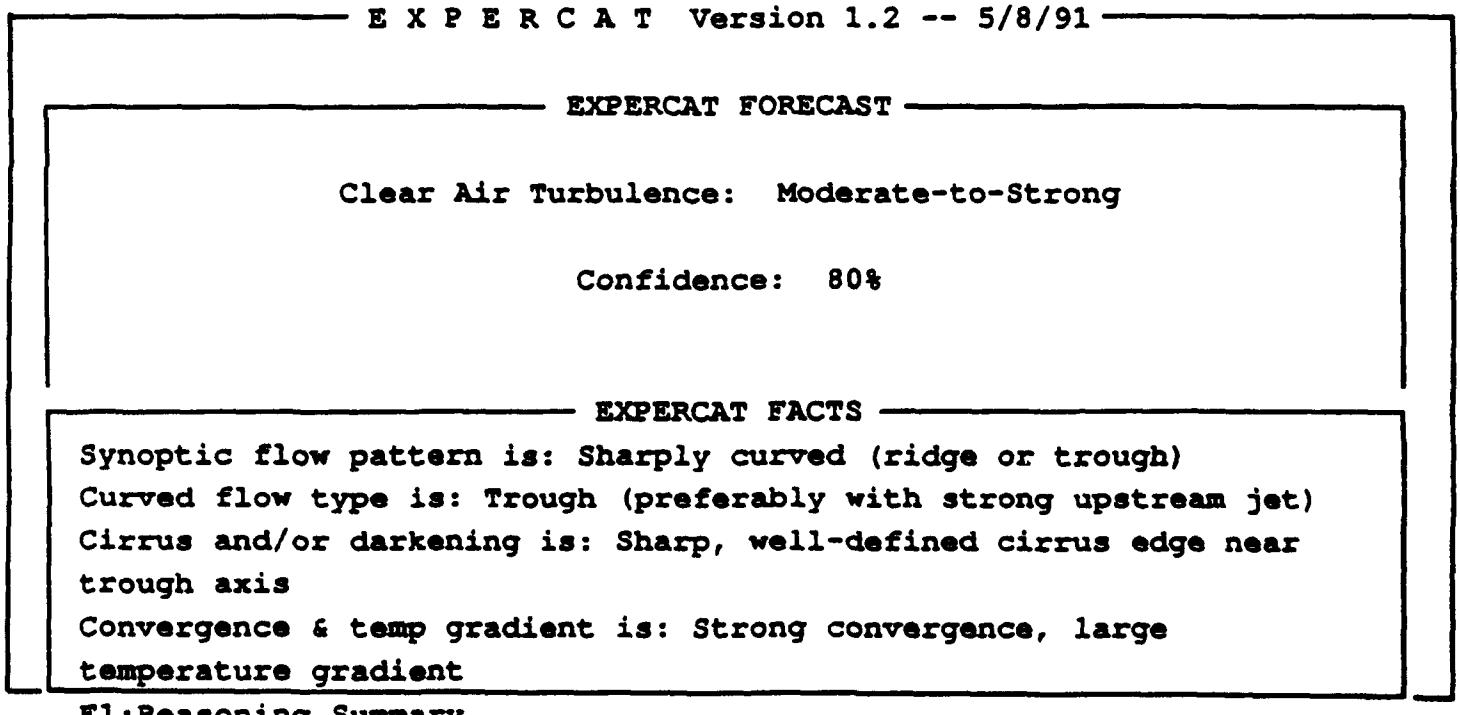


Figure 8. As Figure 7 but invoking 'Reasoning Summary' feature.

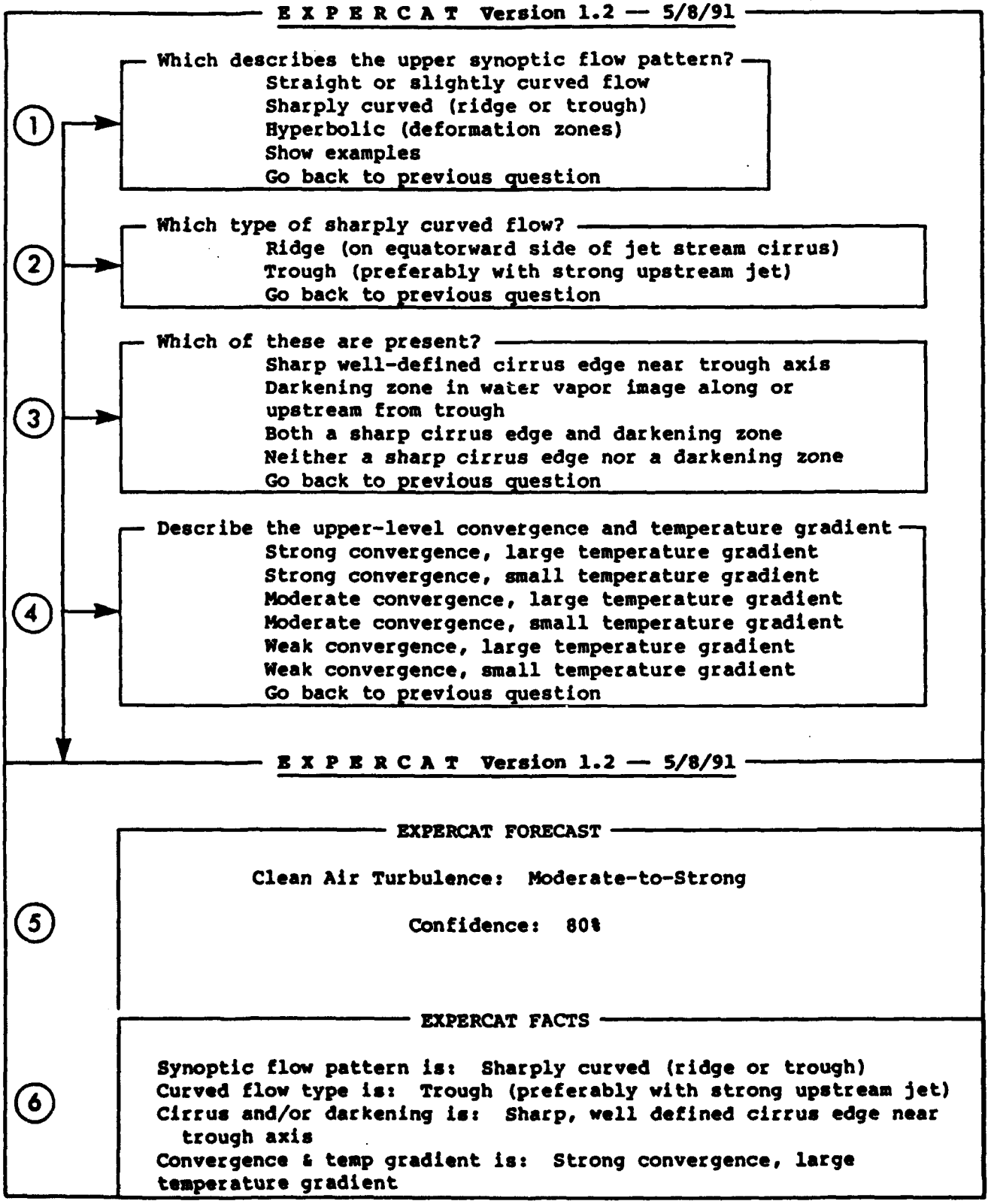


Figure 9. Abbreviated versions of screens used in sample forecast.

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